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Role of soil fungi in nitrogen cycling

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Abstract:
<p>It is often suggested but so far not substantiated that soils with a higher fungal/bacterial (F/B) ratio retain nitrogen better. If this were true, it would be wise for farmers who want to reduce the environmental impact to increase this F/B ratio. We did field studies on experimental plots and on commercial farms and found that lower fertilizer rates led to higher fungal biomass in grassland soils. In incubation studies with intact soil columns we showed that soil with a higher fungal biomass had lower leaching and denitrification rates because of lower mineralization and nitrification rates while maintaining production levels.</p>

Reduction of nitrogen losses to the environment is a target of both farmers and policy makers. It has been suggested that a soil community that is dominated by fungal pathways of decomposition is a feature of grasslands with low potential for N losses. Our research has focused on the interaction between fungi and the N cycle in grassland soils. We aimed to identify changing fungal biomass and its consequence for N cycling.

We found that fungal biomass increased with reduced fertilization and with sward age in 48 grasslands of organic dairy farms on sandy soils in the Netherlands. The relationship between fungal biomass and fertilization rate, manure type and application method was studied in more detail in a field experiment. Here, the positive effect of decreasing fertilization rates on fungal biomass was expressed already within three growing seasons, whereas manure type or application method did not affect fungal biomass. Grass production was not affected by fertilization rate under the conditions studied. Fungal biomass correlated negatively to nitrogen leaching, but this was not necessarily a causal relationship.

Because of the differential effects that arbuscular mycorrhizal fungi (AMF) and saprotrophic (decomposer) fungi can have on nutrient cycling, and because they respond differently to changes in management, we tried to quantify their contribution to total fungal biomass in an incubation study with soil from a field experiment. We found that increased fungal biomass in less fertilized soil was not caused by an increase in AMF alone, part of the increase was due to increase in saprotrophic fungi.

Using intact soil columns from the field experiment, we found that fungi contribute considerably to the reduction of nitrogen losses. We quantified nitrogen losses from soil columns with high and low fungal biomass. The soil with higher fungal biomass had lower leaching and denitrification rates because of lower mineralization and nitrification rates. After addition of 15N-labelled nitrogen, the high fungal biomass soil immobilized more nitrogen into microbial biomass. Plant N uptake did not differ between the soils, which rules out the mechanism of enhanced plant nitrogen uptake through AMF.

We conclude that lower fertilization rates result in a soil with higher fungal biomass that retains nitrogen better while maintaining—at least in the short term—production levels. Therefore, increased fungal biomass is not only a consequence of reduced fertilization, but also a cause of reduced nitrogen losses to the environment.